Simulation of Triplet-Triplet Fusion Diffusion in OLED

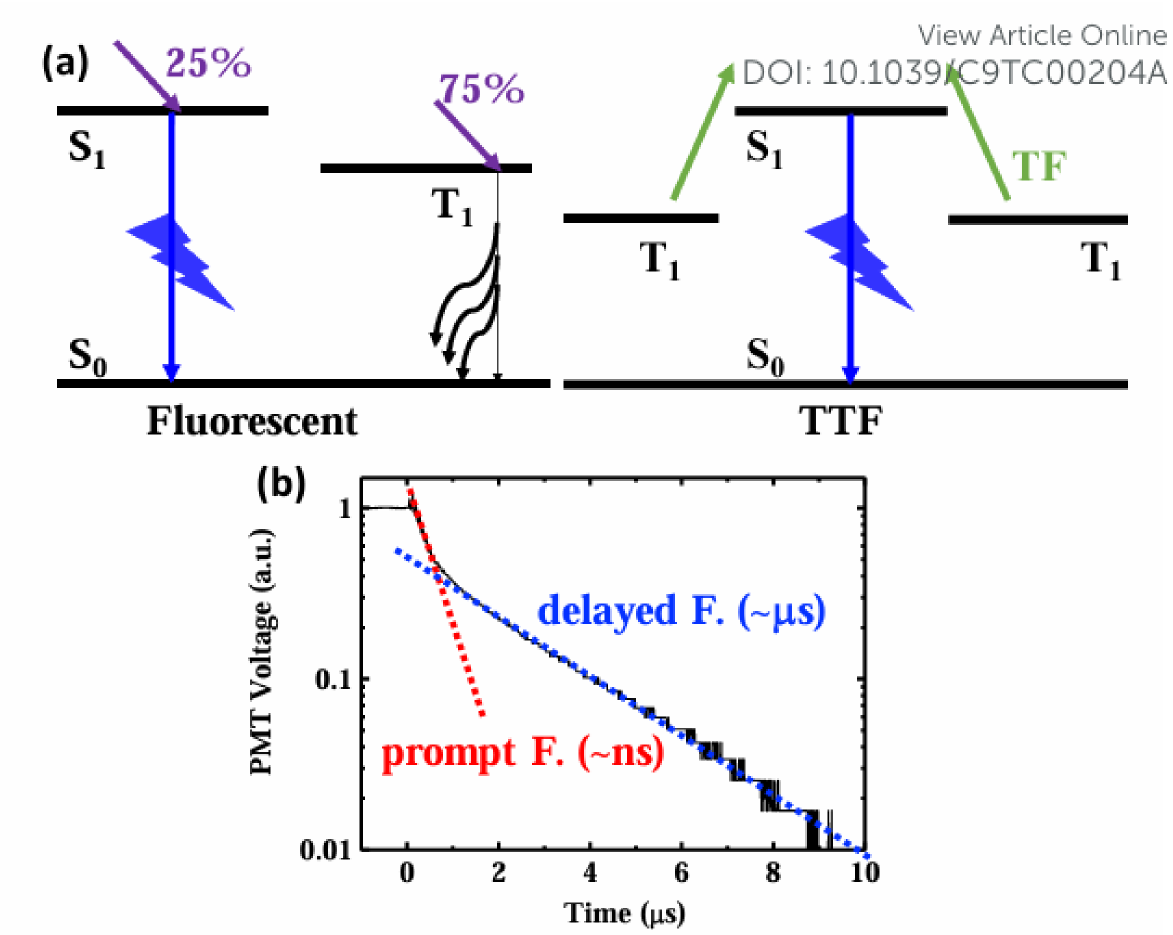

Figure 2 (a) Operation principle of F- and TTF-OLED. (b) Optical intensity of transient EL of TTF-OLED.

Organic excitons contain 75% triplets (3A*) that diffuse and emit in a slow / inefficient phosphorescent process.

Recent trend is to engineer the OLED material so that two triplets can fuse and be converted to efficient emitting singlets. (1A*)

This process is called triplet-triplet fusion (TTF) or sometimes the same is called triplet-triplet annihilation (TTA).

$$3A^* + 3A^* \rightarrow (4/9)\,1A + (1/9)\,1A^* + (13/9)\,3A^*$$

This means that five triplet excitons generate one singlet exciton. Therefore, in addition to the 25% of singlet excitons originally generated, 15% more singlet excitons (75%×1/5) would be generated additionally. This means that 40% singlet exciton formation would be achieved by using this phenomenon.

New OLED materials with TTF capabilities

Deep-blue emitters PAPE and PAPF with two dipheny lanthracene (DPA) moieties linked by fluorene and ether, respectively, together with a single DPA model emitter PAPES are synthesized and characterized.

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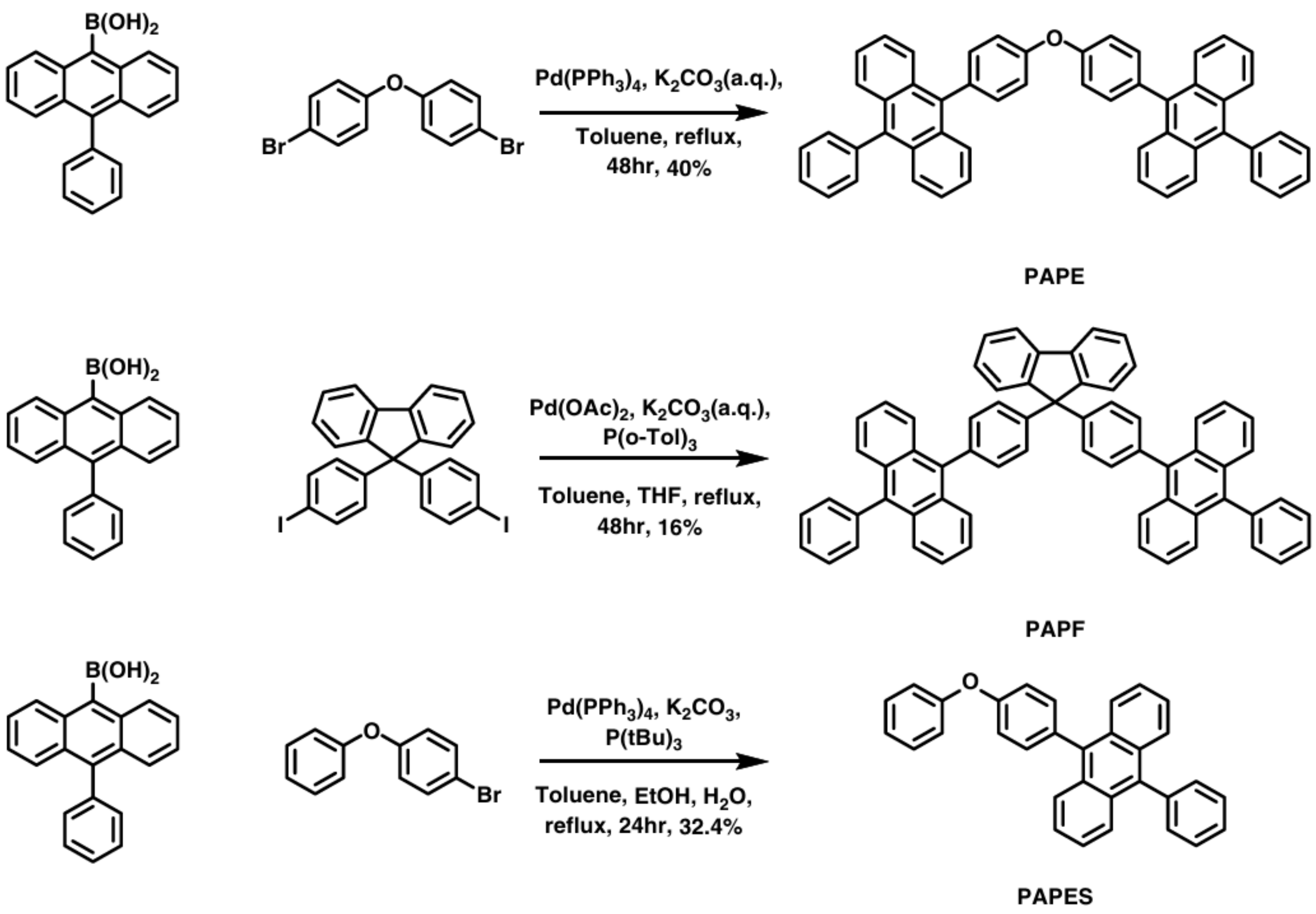


. Reaction scheme for the preparation of **PAPE**, **PAPF**, and **PAPES**.

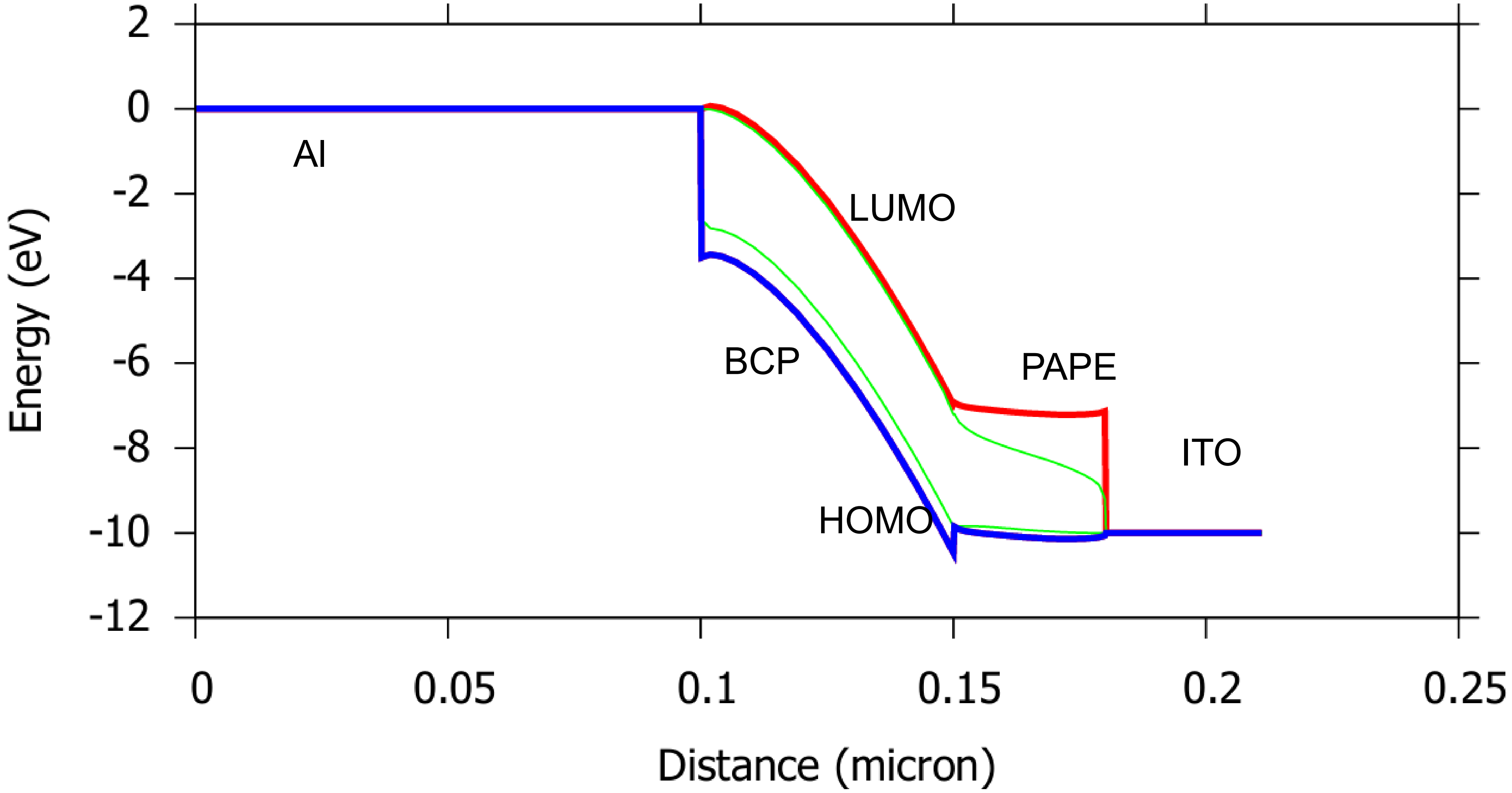
Modeling TT Fusion Effect

$$\frac{\partial S(x)}{\partial t} = \gamma \cdot r(x) \cdot n(x) \cdot p(x) + D_S \cdot \frac{\partial^2 S(x)}{\partial x^2} - \frac{S(x)}{\tau}$$

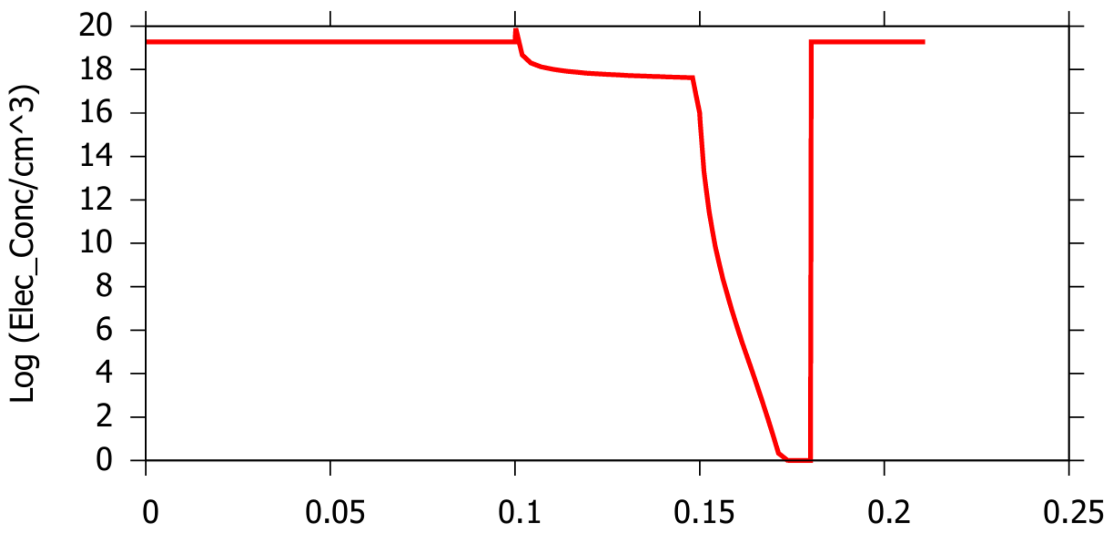
$$- \text{quenching\_terms} + Bt * T(x) * T(x)$$

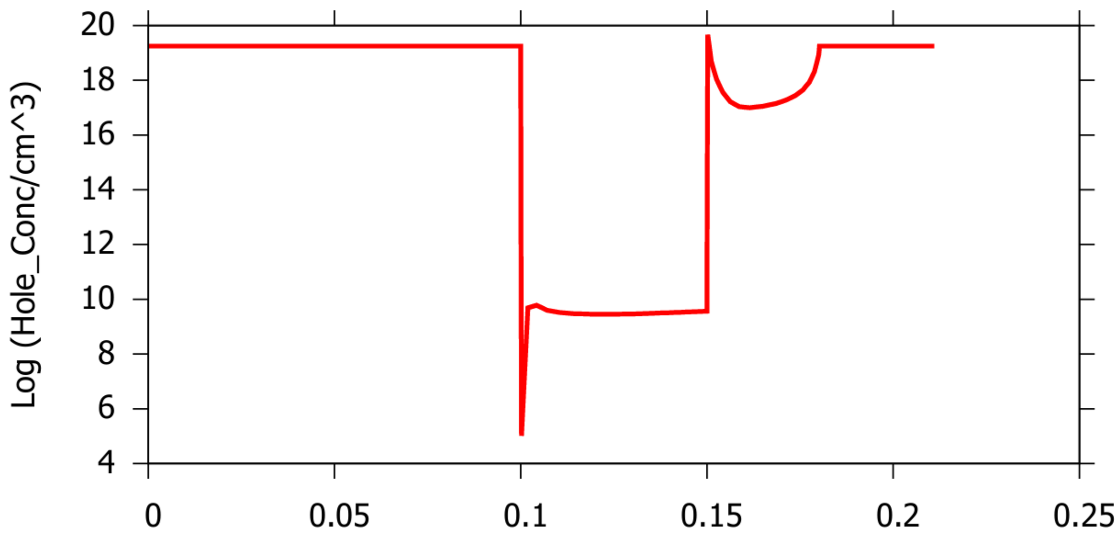
S(x) = Singlet density distribution
T(x) = Triplet density distribution
Bt = Bi-exciton coefficient

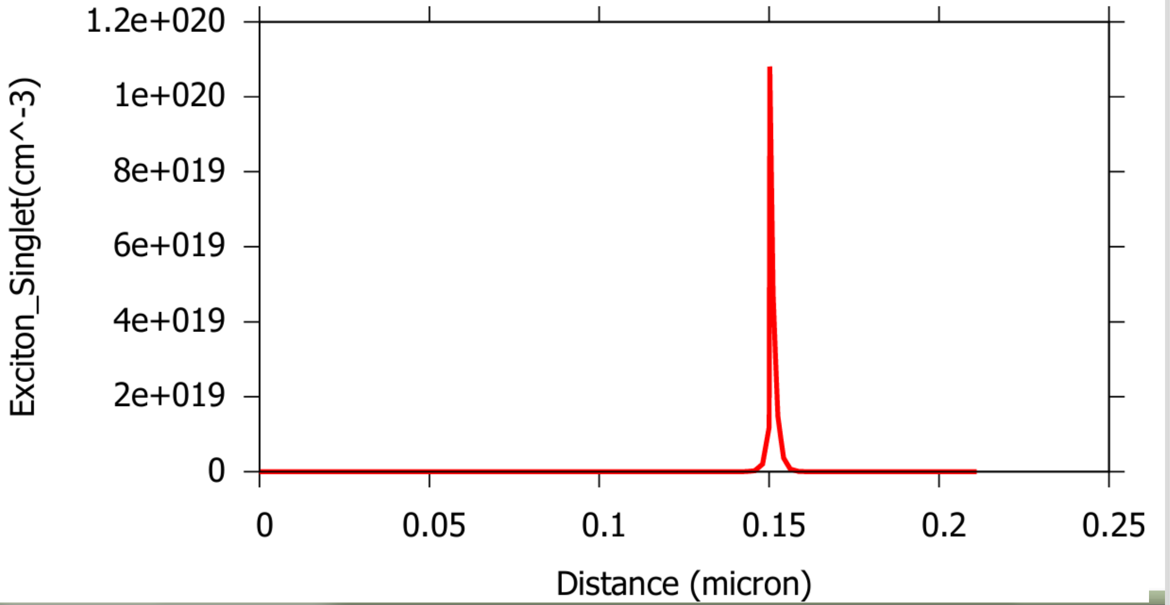
Demo Structure

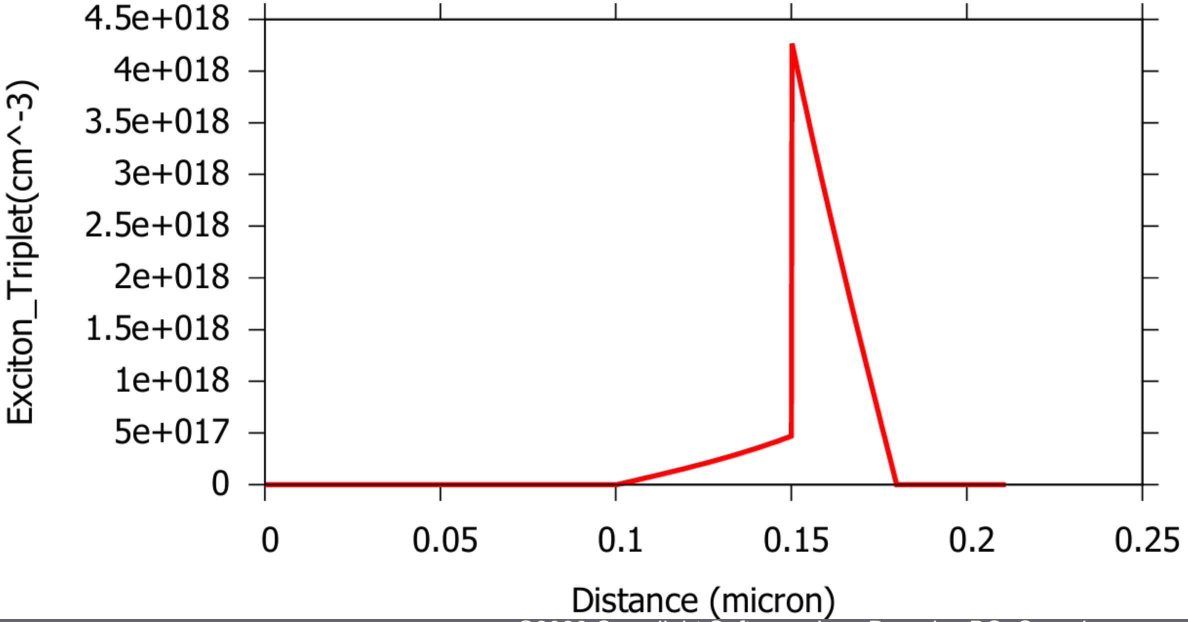


Electron/hole/singlet/triplet distributions

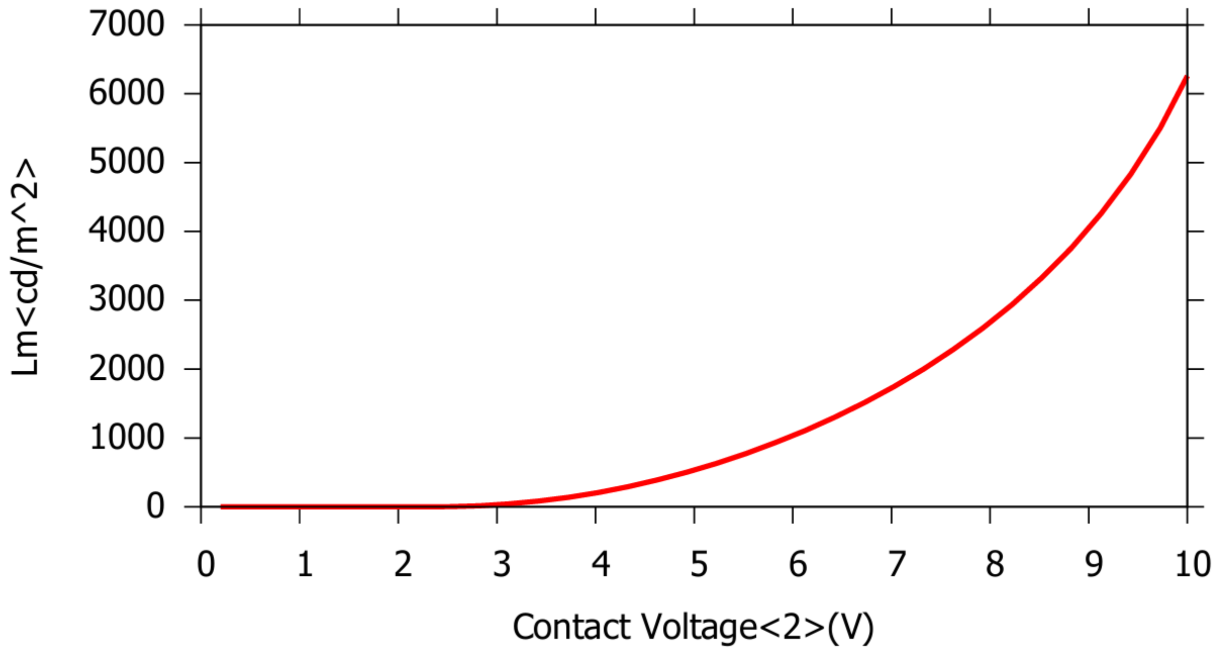


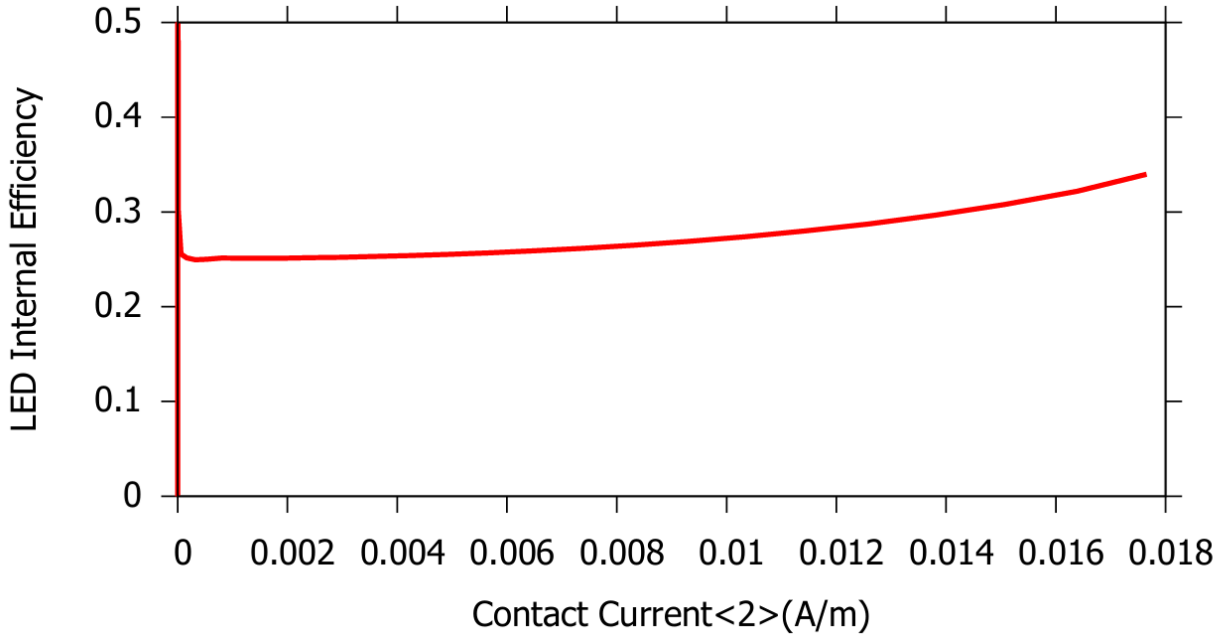






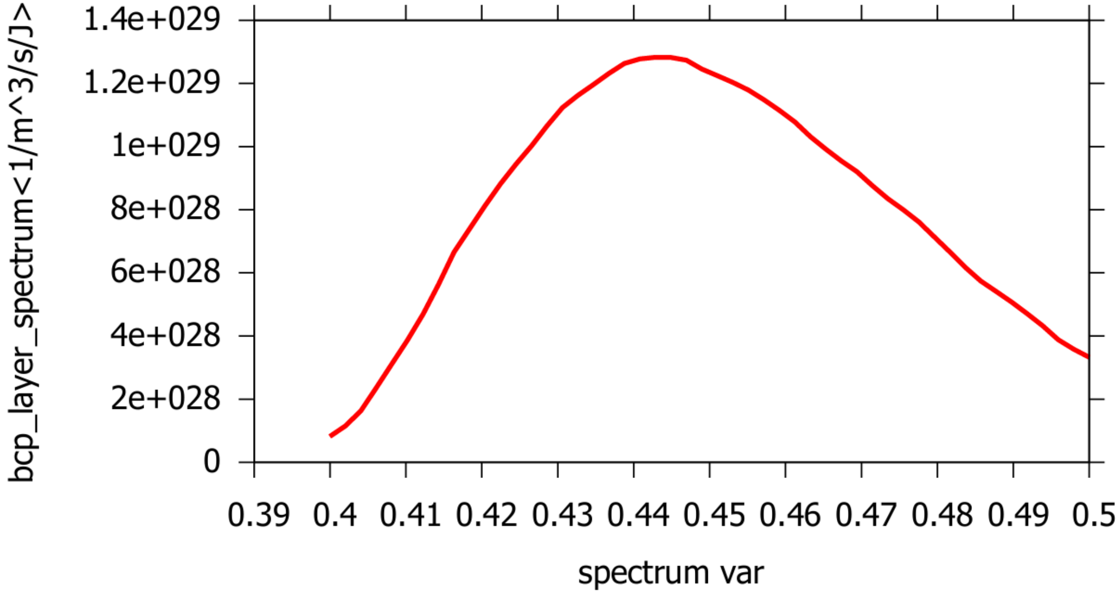
Emission power/Efficiency (with idealized material loss)

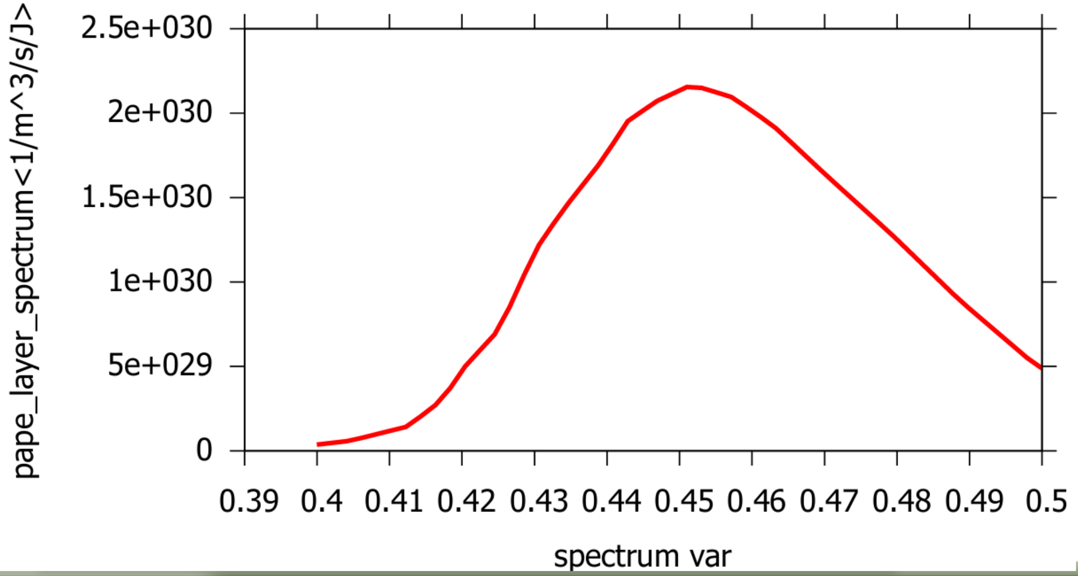




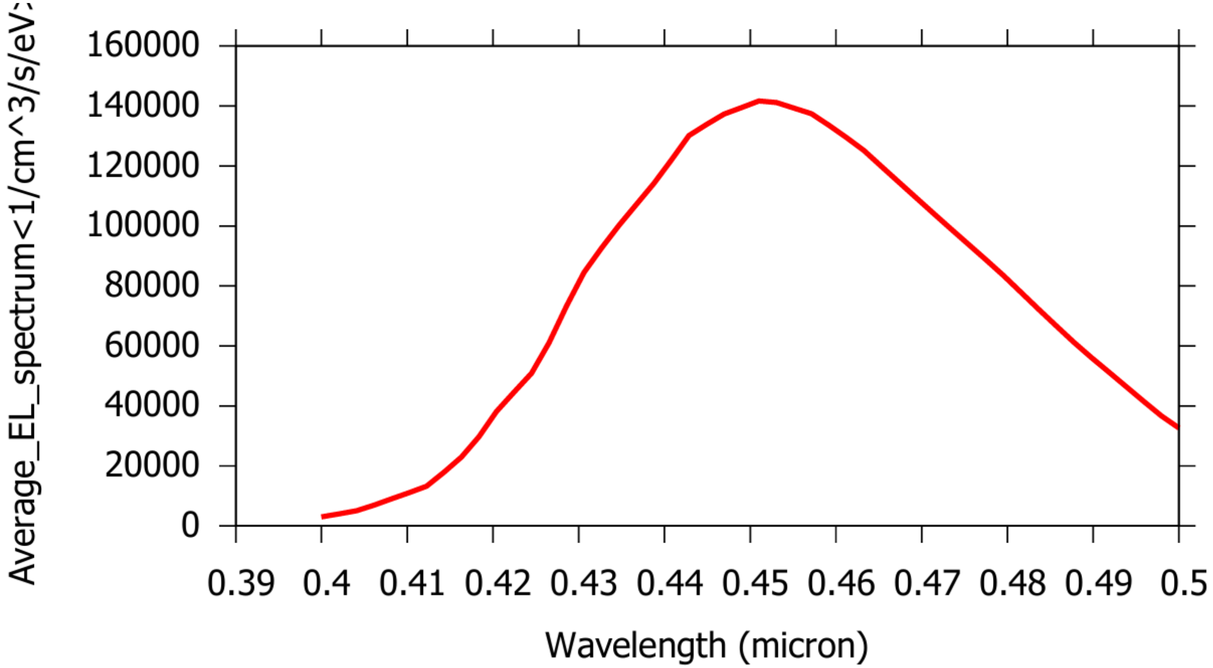
Note the IQE is enhanced beyond the theoretical 25% as triplet density get higher at higher injection condition

EL spectra

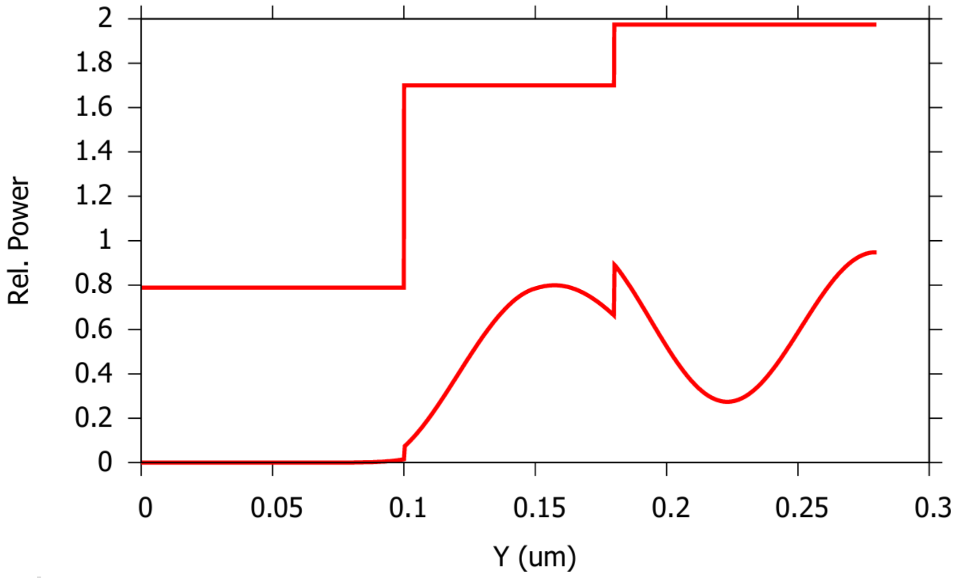


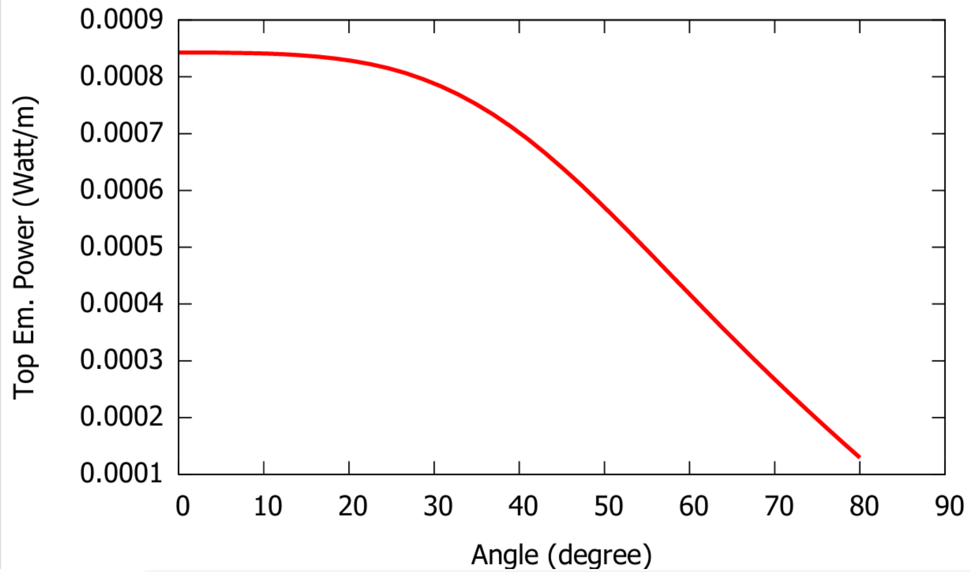


OLED EL spectrum obtained by averaging according to singlet distribution in different layers.

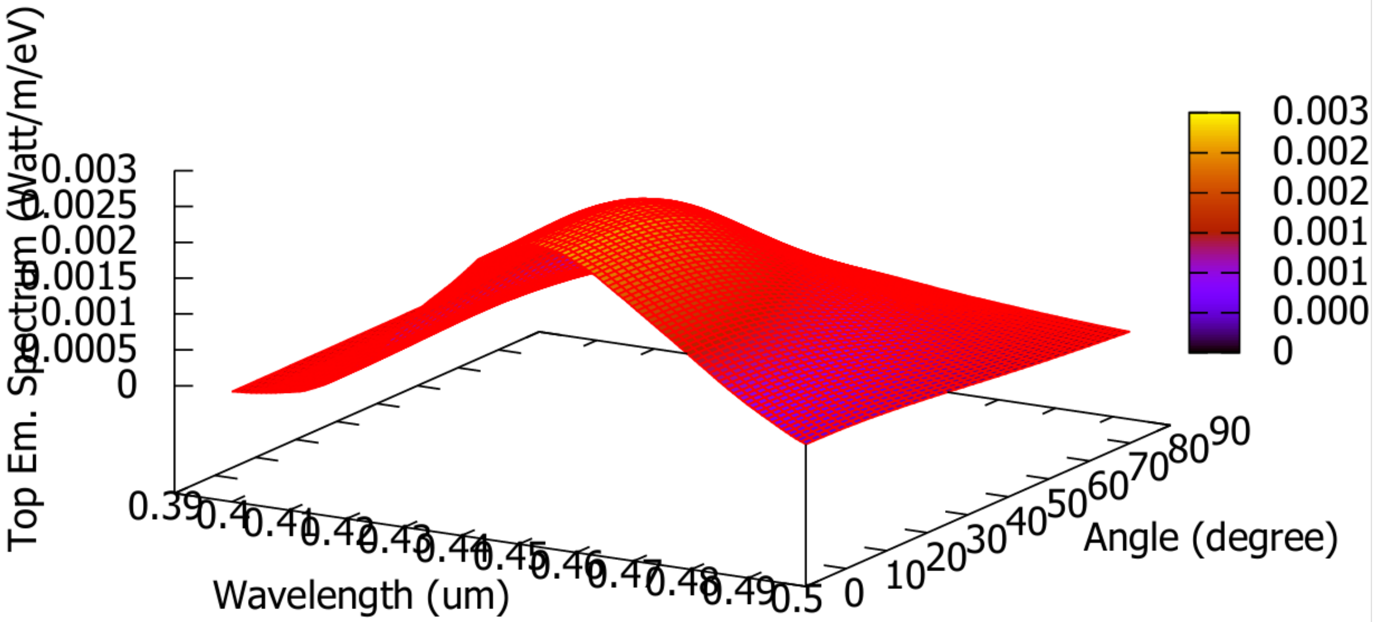


Resonant cavity modeling of emission





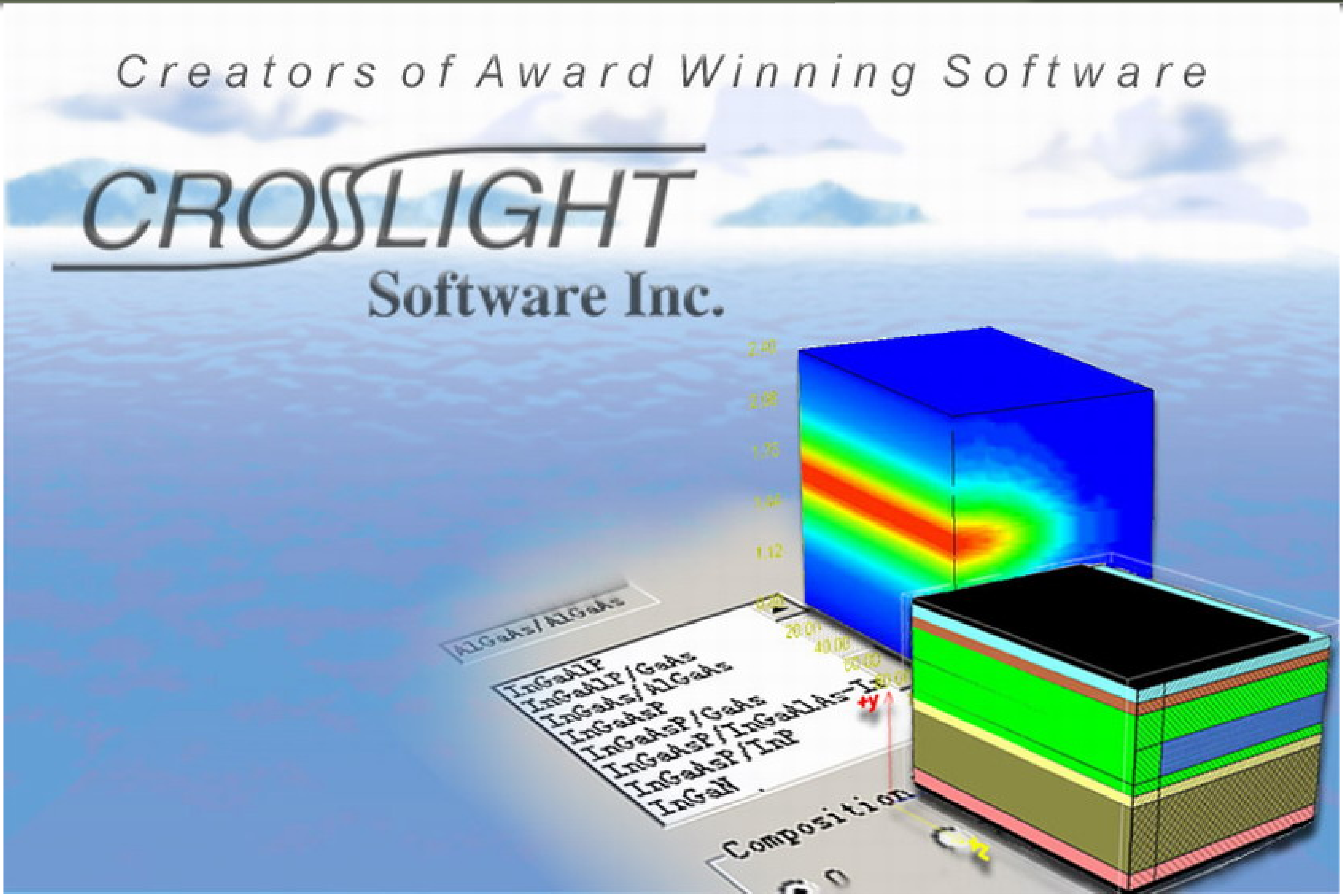
OLED EL spectrum at different emission angles



Summary

- Drift-diffusion model to provide electron/hole distribution in OLED.
- Singlet/triplet excitons are generated from n-p recombination and excitons diffuse and interact.
- Triplet-triplet fusion enhances singlet density resulting in better IQE and more efficient emissions

Thank you for your interests in Crosslight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InGaAlP
InGaAlP/GaAs
InGaAs/AlGaAs
InGaAsP
InGaAsP/GaAs
InGaAsP/InP
InGaN
Composition